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MINERAL CONTENT OF SOUTHERN POULTRY FEEDS AND MINERAL REQUIREMENTS OF GROWING FOWLS

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INTRODUCTION

The mineral subtances which enter into the composition of fowls constitute the ash. These ash constituents stand in a peculiar and interesting relation to the living structures and life processes of animals. Through experimentation the physiologist has determined the effects of many of the minerals upon function and secretion. Minerals are also essential to the construction of the body tissues of the fowl. In this field the soil chemist, the agronomist, the poultryman, the physiologist, and the farmer all find a common interest, for the mineral substances required by fowls come from the soil through the plant to the bird. The force feeding of our fowls, both for growth into broilers and for egg production by mature hens, calls for a higher percentage of mineral nutrients in feedstuffs than was necessary under the old system of less intense production. Since it is so essential that fowls be supplied with sufficient amounts of each mineral element, studies should be conducted to determine whether any of our poultry feeds are deficient and, if so, how the deficiency may be remedied. It may not be possible to exercise a selective choice of feeds which provide an abundance of the various minerals required for rapidity or efficiency in the production of growth or eggs. The present paper deals only with experiments on minerals required in broiler production.

THE PROBLEM

Profitable broiler production begins with the baby chick and extends over a period of about eight weeks, at the end of which time the birds should weigh, as a flock, approximately 1½ pounds each.

Our problem consisted, therefore, in ascertaining (1) the amount of mineral per unit in the bodies of the baby chick and of the 1½-pound broiler; (2) the mineral content of the southern poultry feeds; (3) a proper feed mixture from the standpoint of protein, carbohydrate, and fat; (4) the mineral content of this mixture; and (5) by feeding, whether the

minerals of the feed mixtures were in sufficient quantities for the greatest rate of growth possible.

EXPERIMENTAL METHODS

The baby chicks were produced from a single flock of pure-bred Single-Comb White Leghorns bred at the Station and College poultry plant, and were hatched in one electric incubator, and each lot was housed under similar oil-burning hovers of 100-chick capacity. A room with a concrete floor and ample light and ventilation was used in which to rear the flocks. In this room the birds were confined to runs 6 feet square, having a smooth galvanized-iron floor, laid over the concrete. A hover was set in the center of each run. The experiment was carried on in periods of seven days each, and extended over at least eight periods, or weeks. At the end of each period, after all material which adhered to the feet was carefully removed, the chicks were taken out and weighed, while the run was cleaned. The floor was swept and then scraped, care being taken not to scrape off any of the metal. It was then washed with distilled water, by the aid of a brush. This water was then drained into a pan, the material placed in an evaporating oven, and the moisture driven off. Though every care was taken to be accurate, there is a possibility that some errors may have crept in during these processes.

When fed in ordinary troughs, young chicks have a habit of throwing out their feed with their beaks, especially if they are not particularly hungry, and simply looking for something that might be very palatable to them. In order to avoid this wastage, we constructed the double boxes shown in Plate 18, *a*. Clabbered skim milk, the only liquid allowed, was given in 50-cc beakers, set in the ends of the boxes so that they could not be turned over. Chick-size limestone grit and chick-size oyster shell were given in petri dishes which were placed in another container (Pl. 18, *c*). Dry mash, a grain mixture, and cut green feed were placed in double boxes (Pl. 18, *b*, *d*, *e*). The feed thrown out of these double boxes was caught in the outside chamber, and was easily recovered. Rape was the green feed used (Pl. 18, *f*). The droppings which were deposited in the boxes were easily removed, after drying, by aid of a pair of forceps.

TABLE I.—*Mineral content of the bodies of the fowls* [a]

[Results expressed as parts per hundred]

Age.	Potassium.	Sodium.	Calcium.	Magnesium.	Sulphur.	Chlorin.	Phosphorus.	Iron.
Baby chick [b]	0.2922	0.2774	0.1978	0.0028	0.0107	0.1510	0.355	0.0054
½-pound broiler (Single-Comb White Leghorn)	.2380	.1580	1.0340	.0440	.3030	.0790	1.288	.0056
1-year-old hen (Columbian Wyandotte)	.2750	.1640	1.2970	.0510	.3820	.2080	1.510	.0066

[a] All chemical analyses in this work were made by Mr. Dan M. McCarty, Physiological Chemist, Animal Industry Division, North Carolina Experiment Station.

[b] The baby chicks were taken from the incubator, killed with chloroform, and their abdominal yolk sacs removed.

TABLE II.—*Mineral content of southern poultry feeds*

[Results expressed as parts per hundred]

SEPARATE ANALYSES

Feed.	Number of analyses.	Potassium.	Sodium.	Calcium.	Magnesium.	Sulphur.	Chlorin.	Phosphorus.	Iron.
Cornmeal, bolted	4	0.349	0.072	0.0092	0.1336	0.160	0.0244	0.341	0.004
Pinhead oats	7	.441	.109	.0126	.0704	.236	.0900	.499	.0019
Rolled oats	2	.370	.136	.0430	.1560	.256	.0238	.473	.0062
Whole wheat	13	.435	.039	.0271	.1127	.183	.0630	.436	.007
Whole corn	13	.332	.041	.0127	.1051	.148	.0521	.293	.0044
Wheat middlings	6	.949	1.219	.0980	.3628	.232	.0603	.783	.0052
Bone meal [a]	3	.229	.735	21.1770	.5800	.170	.0900	10.349	.018
Hulled oats	6	.387	.053	.0915	.1465	.204	.0870	.454	.0109
Meat and bone meal [a]	4	.185	.745	12.806	.460	.359	.850	6.560	.0580
Velvet-bean meal	1	1.186	.141	.360	.208	.151	.222	.764	.0126
Soy bean meal (fat extract)	1	1.189	.415	.238	.298	.438	.032	.664	.0300
Peanut meal (fat extract)	1	1.177	.326	.138	.326	.323	.043	.735	.0300
Skim milk	2	.151	.144	.153	.0018	.0424	.065	.136	.0036
Egg, including shell	3	.0103	.200	.608	.0985	.3950	.150	.302	.0103
Rape, green	3	.2510	.008	.0084	.0206	.0354	.093	.1026	.00000076
Limestone grit	2	.0000	.000	30.9700	6.6700	.000	.000	.000	3.330000
Oyster shell	2	.0000	.000	37.951	.4200	.147	.090	.000	.375000
ANALYSES OF FEED IN EACH SACK [b]									
(1a) Corn meal, bolted	....	0.265	0.076	0.0102	0.1318	0.163	0.0232	0.3310	0.0018
(1b) Pinhead oats	....	.467	.115	.0100	.0557	.264	.1050	.5190	.0020
(1c) Rolled oats	....	.370	.149	.0430	.1557	.276	.0249	.4620	.0072
(4d) Cracked wheat	....	.437	.034	.0240	.1027	.182	.0650	.4840	.0022
(1e) Cracked corn	....	.344	.038	.0170	.0667	.195	.0550	.3012	.0028
(1f) Wheat middlings	....	.694	.646	.0840	.3728	.238	.1050	.9420	.0048
(1g) Bone meal	....	.145	.886	22.0550	.5700	.180	.0700	10.3690	.0150
(1h) Meat and bone meal	....	.179	.304	13.333	.2700	.350	.8200	6.5700	.0500
(1i) Hulled oats	....	.374	.084	.056	.1542	.235	.0600	.4060	.0030
(1j) Limestone grit	....	.000	.000	30.970	6.6700	.000	.0000	.0000	3.3300
(1k) Oyster shell	....	.000	.000	37.951	.4200	.147	.0900	.0000	.3750
(1m) Skim milk	....	.151	.144	.153	.0018	.0424	.0650	.1360	.0036

[a] It is probable that in both bone meal and in meat and bone meal considerable tricalcium phosphate [$Ca_3(PO_4)_2$] is lost in burning.

[b] In making up the feed mixtures for these experiments each kind of feed was taken from a single sack.

FEED MIXTURES

The following mixtures were used in these experiments, the proportions being given by weight:

MIXTURE 1

1c Rolled oats	8 parts.
1f Wheat middlings	8 parts.
1h Meat and bone meal	2 parts.
1g Bone meal	1 part.

MIXTURE 2

4d Cracked wheat	3 parts.
1e Cracked corn	2 parts.
1b Pinhead oats	1 part.

MIXTURE 3

1f Wheat middlings	6 parts.
1a Corn meal	3 parts.
1h Meat and bone meal	3 parts.
1g Bone meal	1 part.

MIXTURE 4

4d Whole wheat	3 parts.
1e Cracked corn	2 parts.
1i Hulled oats	1 part.

Table III gives the mineral content of the four feed mixtures.

TABLE III.—*Mineral content of feed mixtures*

[Results expressed as parts per hundred]

Mixture.	Potassium.	Sodium.	Calcium.	Magnesium.	Sulphur.	Chlorin.	Phosphorus.	Iron.
1	0.4742	0.4133	2.61764	0.2809	0.2623	0.1447	1.8281	0.0110
2	.409	.048	.01920	.0820	.200	.0650	.4289	.0023
3	.433	.453	4.81446	.3080	.242	.2482	2.8248	.0153
4	.394	.043	.02699	.0992	.195	.0608	.4100	.0020

TABLE IV.—*Feed and mineral intake of lot 3*

Period and feed.	Quantity of feed consumed.	Potassium.	Sodium.	Calcium.	Magnesium.	Sulphur.	Chlorin.	Phosphorus.	Iron.
	Gm.	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*
FIRST PERIOD:									
Milk	1,510	2.280	2.174	2.310	0.0271	0.6402	0.9815	2.0536	0.0543
Mixture 1	299	1.417	1.235	7.826	.8398	.7842	.4326	5.4660	.0328
Mixture 2	45	.184	.027	.008	.0369	.0900	.0292	.1930	.0010
Grit	76	.000	.000	23.537	5.0692	.0000	.0000	.0000	2.5308
Total	1,930	3.881	3.436	33.678	5.9730	1.5144	1.4433	7.7126	2.6189
SECOND PERIOD:									
Milk	2,492	3.762	3.588	3.812	0.0448	1.0566	1.6198	3.3891	0.0897
Mixture 1	391	1.854	1.616	10.234	1.0983	1.0255	.5657	7.1478	.0430
Mixture 2	275	1.124	.132	.052	.2255	.5500	.1787	1.1794	.0063
Rape	156	.391	.012	.013	.0321	.0552	.1450	.1600	Trace.[a]
Total	3,314	7.131	5.348	14.111	1.4007	2.6873	2.5092	11.8763	.1390
THIRD PERIOD:									
Milk	2,356	3.557	3.392	3.604	0.0424	0.9989	1.5314	3.2041	0.0848
Mixture 1	499	2.366	2.062	13.062	1.4016	1.3088	.7220	9.1222	.0099
Mixture 2	368	1.505	.176	.070	.3017	.7360	.2392	1.5783	.0084
Rape	385	.966	.030	.032	.0793	.1362	.3580	.3950	Trace.
Grit	22	.000	.000	6.813	1.4674	.0000	.0000	.0000	.7326
Oyster shell	11	.000	.000	4.174	.0462	.0161	.0099	.0000	.0412
Total	3,641	8.394	5.660	27.755	3.3386	3.1960	2.8605	14.2996	.8769
FOURTH PERIOD:									
Milk	2,545	3.842	3.664	3.893	0.0458	1.0790	1.6542	3.4612	0.0916
Mixture 2	547	2.237	.262	.105	.4485	1.0940	.3555	2.3460	.0125
Mixture 3	523	2.264	2.369	25.179	1.6108	1.2656	1.2980	14.7737	.0800
Rape	342	.858	.027	.028	.0704	.1210	.3180	.5308	Trace.
Grit	8	.000	.000	2.477	.5336	.0000	.0000	.0000	.2664
Oyster shell	17	.000	.000	6.451	.0714	.0249	.0153	.0000	.0637
Total	3,982	9.201	6.322	38.133	2.7805	3.5845	3.6410	21.1117	.5142
FIFTH PERIOD:									
Milk	3,248	4.904	4.677	4.969	0.0584	1.3771	2.1112	4.4172	0.1196
Mixture 2	1,247	5.100	.598	.239	1.0225	2.4940	.8105	5.3483	.0286
Mixture 3	334	1.446	1.513	16.080	1.0287	.8082	.8289	9.4348	.0511
Rape	321	.805	.025	.026	.0661	.1136	.2985	.3293	Trace.
Grit	18	.000	.000	5.574	1.2006	.0000	.0000	.000	.5994
Total	5,168	12.255	6.813	26.888	3.3763	4.7929	4.0491	19.5296	.7960
SIXTH PERIOD:									
Milk	3,400	5.134	4.896	5.202	0.0612	1.4416	2.2100	4.6240	0.1224
Mixture 2	1,353	5.533	.649	.259	1.1094	2.7060	.8794	5.8030	.0311
Mixture 3	381	1.649	1.725	18.343	1.1734	.9220	.9456	10.7624	.0582
Rape	912	2.289	.072	.076	.1878	.3228	.8481	.9357	Trace.
Grit	33	.000	.000	10.220	2.2011	.0000	.0000	.0000	1.0989
Total	6,079	14.605	7.342	34.100	4.7329	5.3924	4.8831	22.1251	1.3106

[a] These estimates are made on the basis of the green plant as stated in an early part of this paper, and hence the intake is small.

TABLE IV—*Feed and mineral intake of lot 3*—Continued

Period and feed.	Quantity of feed consumed.	Potassium.	Sodium.	Calcium.	Magnesium.	Sulphur.	Chlorin.	Phosphorus.	Iron.
SEVENTH PERIOD:	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*
Milk	3,989	6.023	5.744	6.103	0.0718	1.6913	2.5928	5.4250	0.1436
Mixture 3	332	1.437	1.503	15.984	1.0225	.8034	.8240	9.3783	.0507
Mixture 4	1,236	4.869	.531	.333	1.2261	2.4102	.7514	5.0676	.0247
Rape	880	2.208	.070	.073	.1812	.3115	.8184	.9028	Trace.
Grit	39	.000	.000	12.078	2.6013	.0000	.0000	.0000	1.2987
Total	6,476	14.537	7,848	34.571	5.1029	5.2164	4.9866	20.7737	1.5177
EIGHTH PERIOD:									
Milk	4,203	6.346	6.052	6.430	0.0756	1.7820	2.7319	5.7160	0.1513
Mixture 3	382	1.654	1.730	18.391	1.1765	.9244	.9481	10.7907	.0584
Mixture 4	1,484	5.846	.638	.400	1.4721	2.8938	.9022	6.0844	.0296
Rape	731	1.834	.058	.061	.1505	.2587	.6798	.7500	Trace.
Total	6,800	15.680	8.478	25.282	2.8747	5.8589	5.2620	23.3411	.2393

TABLE V.—*Weights of the chicks at hatching and at the end of each of the eight periods*

Chick No.	Weight at—								
	Hatching.	7 days.	14 days.	21 days.	28 days.	35 days.	42 days.	49 days.	56 days
	Gm.	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*
902	41	57	91	128	135	205	280	350	460
904	45	57	83	123	165	215	253	265	316
906	41	59	88	132	169	245	311	365	430
910	40	60	98	145	197	245	308	355	420
912	42	58	85	110	168	219	287	335	411
914	40	52	65	113	149	205	278	320	400
918	42	59	75	110	151	203	252	275	329
921	42	70	77	108	154	200	271	335	438
922	36	57	90	137	187	250	300	345	410
924	43	59	90	130	150	185	215	240	282
926	44	57	[a] 79	....	....	....	....	....	....
928	42	45	[a] 65	....	....	....	....	....	....
Total	498	690	986	1,236	1,625	2,172	2,755	3,185	3,896

[a] Died.

TABLE VI.—*Percentage increase in weight at the end of each 7-day period*

Chick No.	Period No.							
	1	2	3	4	5	6	7	8
902	28	37	28	5	34	26	20	23
904	21	31	32	25	23	15	4	16
906	30	31	33	21	31	21	14	15
910	50	38	32	26	15	20	13	15
912	27	31	22	28	23	24	14	16
914	23	20	42	24	27	26	13	13
918	28	20	31	26	25	19	8	16
921	40	10	28	29	23	26	19	23
922	36	36	34	26	25	16	13	15
924	27	34	30	13	18	13	10	14
926	22	[a] 27	....	....	....	....	....	....
928	6	[a] 30	....	....	....	....	....	....
Flock average	27	30	31	23	25	21	13	18
Total gain ...gms.	192	296	394	389	547	583	430	711

[a] Died.

TABLE VII.—*Amount of gain in each period and the amount of mineral elements required to build up this amount of tissue, based on the analyses of the bodies of the baby chick and the 1½-pound broiler*

BABY CHICKS

Period.	Gain.	Potassium.	Sodium.	Calcium.	Magnesium.	Sulphur.	Chlorin.	Phosphorus.	Iron.
	Gm.	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*
First	192	0.5610	0.5326	0.3797	0.0053	0.0205	0.2899	0.6816	0.0103
Second	296	.8649	.8211	.5854	.0082	.0316	.4469	1.0508	.0159
Third	394	1.1512	1.0929	.7793	.0110	.0421	.5949	1.3987	.0212
Fourth	389	1.1366	1.0790	.7694	.0108	.0416	.5873	1.3809	.0210
Fifth	547	1.5983	1.5173	1.0819	.0153	.0585	.8259	1.9418	.0295
Sixth	583	1.7035	1.6172	1.1531	.0163	.0623	.8803	2.0696	.0314
Seventh	430	1.2564	1.1928	.8505	.0120	.0460	.6493	1.5265	.0232
Eighth	711	2.0775	1.9723	1.4063	.0199	.0760	1.0736	2.5240	.0383

1½-POUND SINGLE-COMB WHITE LEGHORN BROILERS

Period.	Gain.	Potassium.	Sodium.	Calcium.	Magnesium.	Sulphur.	Chlorin.	Phosphorus.	Iron.
First	192	0.4569	0.3033	1.9852	0.0844	0.5817	0.1516	2.4729	0.0107
Second	296	.7044	.4676	3.0606	.1302	.8968	.2338	3.8124	.0165
Third	394	.9377	.6225	4.0739	.1733	1.1938	.3112	5.0747	.0220
Fourth	389	.9258	.6146	4.0222	.1711	1.1786	.3073	5.0103	.0217
Fifth	547	1.3018	.8642	5.6559	.2406	1.6574	.4321	7.0453	.0306
Sixth	583	1.3875	.9211	6.0282	.2565	1.7664	.4605	7.5090	.0326
Seventh	430	1.0234	.6794	4.4462	.1892	1.3029	.3397	5.5384	.0240
Eighth	711	1.6921	1.1233	7.3517	.3128	2.1543	.5616	9.1576	.0398

TABLE IX.—*Mineral intake supplied by the feed, the outgo by way of the bowel, the amount of each element required to build up the tissue gain, based on the analyses of the bodies of 1½-pound broilers, and the mineral balance*

Period and factor.	Potassium.	Sodium.	Calcium.	Magnesium.	Sulphur.	Chlorin.	Phosphorus.	Iron.
First period:	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*
Intake	3.8810	3.4360	33.6780	5.9730	1.5144	1.4433	7.7126	2.6189
Outgo	1.9847	1.0445	16.7895	2.3497	.6728	.7905	3.8349	.0020
Required	.4569	.3033	1.9852	.0844	.5817	.1516	2.4729	.0107
Balance	+ 1.4394	+ 2.0882	+14.9233	+3.5389	+ .2599	+ .5012	+ 1.4048	+2.6062
Second period:								
Intake	7.1310	5.3480	14.1110	1.4007	2.6873	2.5092	11.8763	0.1390
Outgo	5.7272	2.2206	15.9993	5.1619	2.3389	2.0876	8.3507	.0203
Required	.7044	.4676	3.0606	.1302	.8968	.2338	3.8124	.0165
Balance	+ .6994	+ 2.6598	− 4.9489	−3.8914	− .5484	+ .1878	− .2868	+ .1022
Third period:								
Intake	8.3940	5.6600	27.7550	3.3386	3.1960	2.8605	14.2996	0.8769
Outgo	6.4260	3.0704	17.0000	2.4208	1.3804	3.1790	9.1120	.0340
Required	.9377	.6225	4.0739	.1733	1.1938	.3112	5.0747	.0220
Balance	+ 1.0303	+ 1.9671	+ 6.6811	+ .7445	+ .6218	− .6297	+ .1129	+ .8209
Fourth period:								
Intake	9.2010	6.3220	38.1330	2.7805	3.5845	3.6410	21.1110	0.5142
Outgo	7.7360	4.5841	30.4734	2.6014	1.8724	2.8585	16.9410	.0314
Required	.9258	.6146	4.0222	.1711	1.1786	.3073	5.0105	.0217
Balance	+ .5392	+ 1.1233	+ 3.6374	+ .0080	+ .5335	+ .4752	− .8405	+ .4611
Fifth period:								
Intake	12.2550	6.8130	26.8880	3.3763	4.7929	4.0491	19.5296	0.7960
Outgo	9.5486	3.7437	32.1895	3.6274	2.6184	3.4894	14.9857	.0324
Required	1.3018	.8642	5.6559	.2406	1.6574	.4321	7.0453	.0306
Balance	+ 1.4046	+ 2.2051	+10.9574	− .4917	+ .5171	+ .1276	− 2.5014	+ .7330

TABLE IX.—*Mineral intake supplied by the feed, the outgo by way of the bowels, the amount of each element required to build up the tissue gain, based on the analyses of the bodies of 1½-pound broilers, and the mineral balance*—Continued

Period and factor.	Potassium.	Sodium.	Calcium.	Magnesium.	Sulphur.	Chlorin.	Phosphorous.	Iron.
Sixth period:	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*
Intake	14.6050	7.3420	34.1000	4.7329	5.3924	4.8831	22.1251	1.3106
Outgo	13.1084	5.9358	31.8477	5.0382	3.0062	3.4293	18.0121	.0448
Required	1.3875	.9211	6.0282	.2565	1.7664	.4605	7.5090	.0326
Balance	+ .1091	+ .4851	− 3.7759	− .5618	+ .6198	+ .9933	− 3.3960	+1.2332
Seventh period:								
Intake	14.5370	7.8480	34.5710	5.1029	5.2164	4.9866	20.7737	1.5177
Outgo	13.3769	4.4705	21.7299	3.3716	3.3460	3.8460	16.6019	.0233
Required	1.0234	.6794	4.4462	.1892	1.3029	.3397	5.5384	.0240
Balance	+ .1367	+ 2.6981	+ 8.3949	+1.5421	+ .5675	+ .8009	− 1.3666	+1.4704
Eighth period:								
Intake	15.6800	8.4780	25.2820	2.8747	5.8589	5.2620	23.3411	0.2393
Outgo	16.5110	5.9803	33.2590	5.9082	4.0527	4.5030	19.2760	.0395
Required	1.6921	1.1233	7.3517	.3128	2.1543	.5616	9.1576	.0398
Balance	− 2.5231	+ 1.3744	−15.3287	−3.4263	− .3481	+ .1974	− 5.1576	+ .1600
Total balance	+ 2.8356	+14.6011	+20.5406	−2.5371	+2.2231	+2.6542	−12.0312	+7.5870

TABLE VIII.—*Total weight of mineral in the droppings for each period*

Period.	Potassium.	Sodium.	Calcium.	Magnesium.	Iron.	Phosphorus.	Sulphur.	Chlorin.	Total droppings.
	Gm.	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*
First	1.9847	1.0445	16.7695	2.3497	0.0020	3.8349	0.6728	0.7905	168.2
Second	5.7272	2.2206	15.9993	5.1619	.0203	8.3507	2.3389	2.0876	369.5
Third	6.4260	3.0704	17.0000	2.4208	.0340	9.1120	1.3804	3.1790	340
Fourth	7.7363	4.5841	30.4734	2.6014	.0314	16.9410	1.8724	2.8585	524.5
Fifth	9.5486	3.7437	32.1895	3.6274	.0324	14.9857	2.6184	3.4894	541
Sixth	13.1084	5.9358	31.8477	5.0382	.0448	18.0121	3.0062	3.4293	641
Seventh	13.3769	4.4705	21.7299	3.3716	.0233	16.6019	3.3460	3.8460	641
Eighth	16.5110	5.9803	33.2590	5.9882	.0395	19.2760	4.0527	4.5030	790

DISCUSSION OF RESULTS

In studying the mineral content of poultry feeds we found that the different samples of products grown in different sections of the country, or even different sections of a State, or on different plots of ground, vary in their inorganic content. Therefore we have given the averages of a large number of analysis from different lots of the same kind of feeds in order to show the average of these specific analyses (Table II) and later a tabulation of the analyses of just the feeds used in these experiments (Table III). The latter table will enable us to determine definitely just the amount of mineral taken in in these feeding experiments. Not only the poverty of the soil, but also seasonal variations from year to year, such as drouth, may affect the mineral content of the feed.

In the baby chick the bones are very thin walled and bend easily, indicating that thorough calcification has not taken place in all parts. It is to be expected that later in the life of the chick there would be a greater amount of mineral in the bones and consequently a greater percentage in the total weight of the bird. If the results of the analyses

which were carried on with the bodies of baby chicks and of 1½-pound broilers be studied, it will be noted that there is a material increase of the greater essential inorganic constituents of the bone—namely, calcium, magnesium, and phosphorus. The baby chick is provided with down. This is gradually replaced with a coat of feathers as the chick develops, which calls for an increase of sulphur. It will also be noted that in this element there has been a material increase. To carry our comparative study a step farther, it will be noted that, as the bird develops to maturity, there is a still greater increase in calcium, magnesium, phosphorus, and sulphur, though the iron content is only slightly increased.

The bird has no sweat glands and only one oil gland, the latter a double lobulated tubular gland located dorsally at the base of the tail. This gland furnishes oil for the bird to distribute to each feather by the aid of its beak. The excretions of the body of the fowl are cast off by way of the lungs, kidneys, and intestinal tract. The ureters, large intestine, oviduct, and vasa deferentia all empty into a reservoir, an expansion of the terminal end of the gut, called the "cloaca," which in turn empties through the anus to the external world. This arrangement makes the isolation of elements eliminated by the kidneys a difficult task; in fact, it is impossible except through surgical interference, and this has many difficulties. In these particular experiments we have not attempted this.

In an average of two lots in this series of experiments the following quantities of feeds were required to produce 1 gm. of gain in weight: Milk, 7.49 gm.; mash and grain mixtures, 2.91 gm.; green feed, 1 gm.; total 11.44 gm. In these cases the feed was kept constantly before the flocks, so that the consumption was a maximum amount and by selection, so far as the milk, mash, and grain mixtures were concerned. The rape, finely chopped, and the milk were likewise kept in separate containers. Thus, where the chicks in their first eight weeks are given all the sour skim milk and green feed they will consume, there will be required approximately 3 gm. of grain and mash per gram of gain in body weight. In these two lots it was found that 75.2 per cent of the carbohydrates were digested and 80.2 per cent of the fat. These are the averages for the eight periods, the digestibility varying from period to period.

The methods used to separate the ammonia and uric acid of the feces from the undigested protein of the feed were not considered to be sufficiently accurate to give here. The problem of separating the mineral elements from those passed out with the feces unused is a quite different matter. If it were possible to separate the urine from the feces by surgical interference, there would yet remain that eliminated by way of the bowel, which could not be separated from that taken with the food and not utilized. At this time there seems to be only one practical way to measure mineral requirements—that is, by comparing the intake with the outgo and the amount required to construct the tissue gain, and to study the mineral balances left over unaccounted for.

From Table I, which gives the mineral content of the bodies of fowls, may be seen the requirement in utilizable mineral needed to construct a given gain. From the above estimate of the quantity of feeds to produce a pound of gain can be estimated the amount of mineral elements contained in the feed.

The mineral intake will fluctuate with the kinds of materials given in addition to the dry mash and the grain mixtures. By a study of the table of average analyses (Table II) it will be seen that milk contains quite a large quantity of phosphorus, calcium, sodium, and potassium, and hence the intake of sour skim milk, if the chicks are given all they will consume, supplies much in the way of mineral elements. Thus, in the first period 58 per cent of the potassium, 63 per cent of the sodium, 6 per cent of the calcium[1] 0.0045 per cent of magnesium,[1] 42 per cent of sulphur, 68 per cent of chlorin, 26 per cent phosphorus, and 2 per cent of iron[1] were furnished by the sour skim milk.

In the second period 52 per cent of the potassium, 67 per cent of the sodium, 27 per cent of the calcium, 3 per cent of the magnesium, 39 per cent of the sulphur, 64 per cent of the chlorin, 28 per cent of the phosphorus, and 64 per cent of the iron were furnished by the sour skim milk.

In the third period 42 per cent of the potassium, 60 per cent of the sodium, 13 per cent of the calcium, 1 per cent of the magnesium, 31 per cent of the sulphur, 53 per cent of the chlorin, 22 per cent of the phosphorus, and 9 per cent of the iron were furnished by the milk.

In the fourth period 41 per cent of the potassium, 57 per cent of the sodium, 10 per cent of the calcium, 1 per cent of the magnesium, 30 per cent of the sulphur, 45 per cent of the chlorin, 16 per cent of the phosphorus, and 17 per cent of the iron were furnished by the sour skim milk.

In the fifth period 40 per cent of the potassium, 68 per cent of the sodium, 18 per cent of the calcium, 1 per cent of the magnesium, 28 per cent of the sulphur, 52 per cent of the chlorin, 22 per cent of the phosphorus, and 14 per cent of the iron were furnished by the sour skim milk.

In the sixth period 35 per cent of the potassium, 66 per cent of the sodium, 15 per cent of the calcium, 1 per cent of the magnesium, 26 per cent of the sulphur, 45 per cent of the chlorin, 20 per cent of the phosphorus, and 9 per cent of the iron were furnished by the sour skim milk.

In the seventh period 41 per cent of the potassium, 73 per cent of the sodium, 17 per cent of the calcium, 1 per cent of the magnesium, 32 per cent of the sulphur, 52 per cent of the chlorin, 26 per cent of the phosphorus, and 9 per cent of the iron were supplied by the sour skim milk.

[1] It must be remembered that all the mineral elements in the grit are not liberated for use in the same period in which it is consumed, since all the grit will not be ground for about two weeks.

In the eighth period 40 per cent of the potassium, 70 per cent of the sodium, 25 per cent of the calcium, 2 per cent of the magnesium, 32 per cent of the sulphur, 51 per cent of the chlorin, 24 per cent of the phosphorus, and 63 per cent of the iron were supplied by the sour skim milk.

If we consider the total mineral nutrients that would have been supplied by the feed ingested, leaving out the milk, there would have been ample furnished in any of the eight periods.

If the birds had received neither milk nor mash, there would have been a deficiency in the first period in all mineral elements except potassium and magnesium provided that the same quantity of feed was consumed as a grain mixture and that the consumption of shell or limestone as grit was not considered. In the second period there would have been a deficiency in sodium, calcium, potassium, and iron. In the third period there would have been a deficiency in sodium, calcium, phosphorus, and iron. In the fourth period there would have been the same deficiency as in the third period. In the fifth, sixth, and seventh periods there would have been a deficiency in calcium alone, and a deficiency in calcium, sodium, and phosphorus in the eighth period.

In Table IX there is an apparent balance of calcium of 20 gm. unaccounted for, and in this connection it must be remembered there would be at least 1 or 2 gm. of limestone grit per bird still remaining in the gizzards at the end of these tests. This would likewise affect the magnesium, leaving a small balance, and the same holds good for the iron, since the limestone used in these experiments contained 3 per cent of iron. The summary of the eight periods indicates an apparent shortage of phosphorus and a slight shortage of magnesium.

To supply the proper amount of phosphorus, magnesium, and calcium to growing chicks, in mashes consisting of such mill feeds as middlings and ground oats there should be added meat and bone meal, or bone meal, or meat meal. Sour skim milk and buttermilk, if given in sufficient quantities, aid in making good the mineral shortages as well as providing food hormones, which have a stimulating effect upon the growth of the young, as shown by work in this and other laboratories.

SUMMARY

The mineral content of southern poultry feeds varies in different kinds of feed and in different lots of the same kind. This difference is influenced by weather conditions, such as drouth, and by the different mineral contents of the soil.

In the development of the broiler from the baby chick there is a gradual increase in the requirements of calcium, magnesium, phosphorus, and sulphur. To supply this increase and to attain the best growth there must be added to a ration consisting of mill products and ground grain, such products as meat meal, bone meal, meat and bone meal, and sour skim milk or buttermilk.

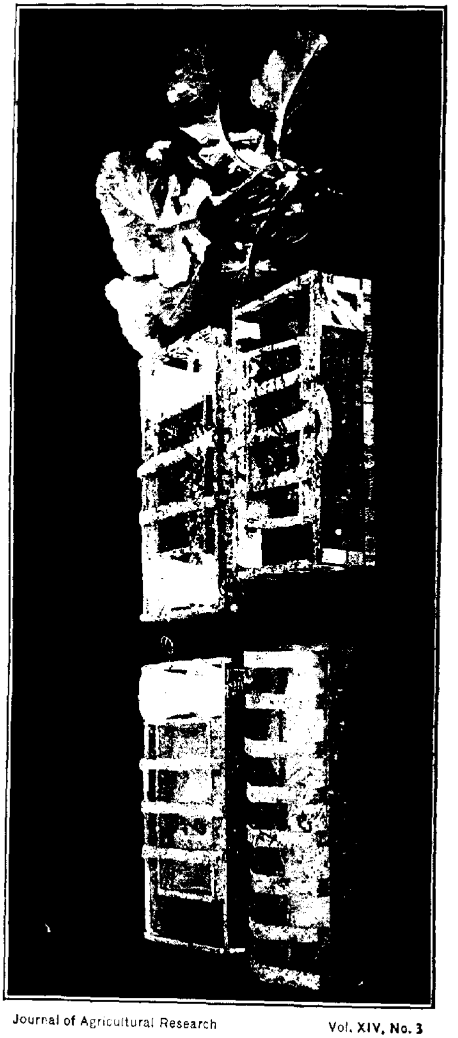

PLATE 18

Feeding utensils used in the feeding experiments with chicks: *a*, Beakers for the sour skim milk; *b*, container for the dry mash; *c*, container for grit or shell; *d*, container for the grain mixture; *e*, container for the green feed; *f*, rape used as green feed.

FEMALE LEPIDOPTERA AT LIGHT TRAPS

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INTRODUCTION

It appears to be the generally accepted theory that in the Lepidoptera practically all individuals taken at a light trap are males, and that of the few females so captured all have oviposited previously. During the summer of 1916 extended observations were made at the Hagerstown, Maryland, field station of the Bureau of Entomology in an effort to secure some definite information as to the relative proportions of the sexes of moths attracted to the light and the percentage of gravid females among those so taken. The purpose of this paper is to give a brief account of the methods employed to obtain material and a summary of the facts brought out by a detailed examination of such material.

The attracting light used was an arc lamp of 300 candlepower hung in an inverted truncated cone of heavy tin. One-half of the cone which would otherwise encircle the lamp was cut away; the narrow (lower) end of the cone was fitted in the circular opening in the top of the trap. Immediately below this opening are arranged several plates of glass at angles to direct the moths downward into the body of the trap. The trap is 12 by 14 inches and 20 inches high. Two sides are of wire mesh, the other sides and the top and bottom being of wood. To kill the captured insects, the trap was placed in a tightly constructed box with a small vessel of carbon disulphid placed at the top of the trap.

The individuals of some twenty-odd species were preserved in alcohol, with the date of each collection. Later these were determined as to sex and the number of males and females tabulated for each date. The females were carefully dissected and tabulated as to the stage of ova development.

[1] The writer wishes to express his appreciation of the assistance given by Mr. Harry L. Parker, of the Hagerstown station, who separated the individuals of Caenurgia into the two species represented; and to acknowledge the help received from other men of the station.

No attempt was made to determine specifically the individuals of the genus Feltia, of which it is probable that the following four species were taken: *Feltia subgothica* Haworth, *F. annexa* Treitschke, *F. gladiaria* Morrison, and *F. jaculifera* Guenée.

The material collected and examined embraces a little over 11,000 individuals, representing 3 families and about 20 species. Table I gives the results of an examination of this large number of moths to determine the sex. No extended résumé is attempted in the text beyond a brief statement of some of the more salient facts.

Of the 11,222 moths examined, 8,025, or 71.5 per cent, were males; 3,197, or 28.5 per cent, were females. In only one species, *Noctua c-nigrum*, did the females taken equal or exceed the males.

TABLE I.—*Number and percentage of males and females of various species of Lepidoptera taken at a light trap, Hagerstown, Md., 1916*

Species.	Number of males.	Number of females.	Total.	Percentage of males.	Percentage of females.
Apantesis vittata Fabricius	1,158	25	1,183	97.9	2.1
Apantesis arge Drury	14	3	17	82.3	17.7
Estigmene acraea Drury	404	69	473	85.4	14.6
Diacrisia virginica Fabricius	66	8	74	88.0	12.0
Isia isabella Smith and Abbot	256	42	298	86.0	14.0
Halisidota tessellaris Smith and Abbot	282	123	405	69.6	30.4
Datana ministra Drury	47	19	66	71.2	28.8
Arsilonche albovenosa Goeze	111	11	122	90.0	10.0
Autographa biloba Stephens	38	2	40	95.0	5.0
Autographa simplex Guenée	223	71	294	75.8	24.2
Meliana diffusa Walker	159	19	178	89.4	10.6
Polia renigera Stephens	192	77	269	71.4	28.6
Caenurgia erechtea Cramer	1,437	833	2,270	64.1	35.9
Caenurgia crassiuscula Haworth	973	566	1,539	64.5	35.5
Cirphis unipuncta Haworth	552	424	976	56.5	43.5
Noctua c-nigrum Linnaeus	95	107	202	47.0	53.0
Feltia spp	2,018	798	2,816	71.7	28.3
Total	8,025	3,197	11,222	71.5	28.5

Table II gives the percentage of gravid females and shows that of 3,197 individuals dissected, 1,857, or 58 per cent, were gravid. These gravid females make up 16.6 per cent of the 11,222 moths examined.

It will be noted that all the females of four of the six species of Arctiidae under observation were gravid, and in the two other species the gravid females represent 85.5 per cent and 96 per cent of females collected. These facts, together with data as to the number and development of the eggs, are to be found in Table III.

TABLE II.—*Number and percentage of gravid female Lepidoptera taken at a light trap, Hagerstown, Md., 1916*

Species.	Number of females taken.	Spent.	Gravid. Number.	Gravid. Per cent.
Apantesis vittata Fabricius	25	0	25	100.0
Apantesis arge Drury	3	0	3	100.0
Estigmene acraea Drury	69	10	69	85.5
Diacrisia virginica Fabricius	8	0	8	100.0
Isia isabella Smith and Abbot	42	0	42	100.0
Halisidota tessellaris Smith and Abbot	123	5	118	96.0
Autographa biloba Stephens	2	2	0	0.0
Autographa simplex Guenée	71	19	52	73.0
Meliana diffusa Walker	19	12	7	37.0
Polia renigera Stephens	77	10	67	87.0
Caenurgia erechtea Cramer	833	389	444	53.3
Caenurgia crassiuscula Haworth	566	290	276	48.7
Cirphis unipuncta Haworth	424	85	339	80.0
Noctua c-nigrum Linnaeus	107	58	49	54.8
Arsilonche albovenosa Goeze	11	0	11	100.0
Feltia spp.	798	394	404	50.6
Datana ministra Drury	19	0	19	100.0
Total	3,197	1,340	1,857	58.0

TABLE III.—*Condition of the ovaries of Lepidoptera taken at a light trap, Hagerstown, Md., 1916*

APANTESIS VITTATA

Date.	Number taken.	Condition of ovaries. Spent.	Condition of ovaries. Gravid.	Number and development of eggs.
July 26	2	0	2	11D; 93D.
30	3	0	3	116D; 96D; 123D.
31	2	0	2	67D; 76D.
Aug. 3	6	0	6	129D; 146D; 122D; 131D; 96D; 224D.
4	5	0	5	78D; 89D; 108D; 95D; 113D.
6	3	0	3	77D; 53D; 47D.
8	1	0	1	103D.
9	1	0	1	139D.
15	1	0	1	166D.
22	1	0	1	113D.

APANTESIS ARGE

Date.	Number taken.	Spent.	Gravid.	Number and development of eggs.
July 20	1	0	1	156D.
26	1	0	1	97D.
Aug. 25	1	0	1	129D.

TABLE III.—*Condition of the ovaries of Lepidoptera taken at a light trap, Hagerstown, Md., 1916*—Continued

ESTIGMENE ACRAEA

Date.		Number taken.	Condition of ovaries.		Number and development of eggs.
			Spent.	Gravid.	
June	23	1	1	0	
	29	1	0	1	187D.
July	1	1	0	1	98D.
	2	1	0	1	117D.
	14	1	1	0	
	27	1	0	1	203D.
	30	1	0	1	128D.
	31	7	0	7	All fully developed but not counted.
Aug.	1	1	0	1	153D.
	3	5	0	5	All fully developed but not counted.
	4	1	1	0	
	5	5	0	5	Do.
	6	1	1	0	
	8	3	1	2	147D; 138D.
	9	1	1	0	
	10	2	1	1	186D.
	11	1	0	1	227D.
	13	1	0	1	236D.
	17	2	0	2	All fully developed but not counted.
	18	3	1	2	Do.
	19	3	1	2	Do.
	20	3	1	2	Do.
	21	4	0	4	Do.
	22	3	0	3	Do.
	23	5	0	5	Do.
	24	5	0	5	Do.
	25	4	0	4	Do.
	28	2	0	2	Do.

DIACRISIA VIRGINICA

June	28	2	0	2	238D; 609D.
July	2	1	0	1	514D.
	24	1	0	1	488D.
	28	1	0	1	378D.
	29	1	0	1	471D.
	31	1	0	1	538D.
Aug.	6	1	0	1	493D.

ISIA ISABELLA

July	30	3	0	3	217D; 165D; 126D; 155D.
	31	5	0	5	287D; 175D; 214D; 391D; 393D.
Aug.	1	2	0	2	257D; 218D.
	2	1	0	1	212D.
	3	1	0	1	223D.
	4	7	0	7	Averaged 252D.
	5	7	0	7	Averaged 217D.
	6	1	0	1	158D.
	8	2	0	2	164D; 192D.
	9	3	0	3	387D; 320D; 392D.

TABLE III.—*Condition of the ovaries of Lepidoptera taken at a light trap, Hagerstown, Md., 1916*—Continued

ISIA ISABELLA—continued

Date.		Number taken.	Condition of ovaries.		Number and development of eggs.[a]
			Spent.	Gravid.	
Aug.	10	1	0	1	129D.
	19	1	0	1	229D.
	21	1	0	1	274D.
	22	3	0	3	287D; 278D; 239D.
	23	1	0	1	285D.
	24	1	0	1	377D.
	25	1	0	1	248D.
Sept.	1	1	0	1	116D.

HALISIDOTA TESSELLARIS

July	1	4	1	3	137D; 218D; 186D.
	2	3	0	3	298D; 150D(e); 200D(e).
	3	13	0	13	293D; 68D; 98D; 128D; 9 averaged 167D.
	4	9	0	9	5 averaged 257D; 4 averaged 137D.
	6	4	0	4	168D; 157D; 128D; 92D.
	7	6	0	6	128D; 153D; 4 averaged 206D.
	8	21	0	21	6 averaged 260D; 15 averaged 180D.
	10	4	0	4	178D; 58D; 100D(e); 75D(e).
	14	2	0	2	280D; 124D.
	18	6	0	6	278D; 238D; 217D; 3 averaged 250D(e).
	19	4	0	4	283D; 3 averaged 225D(e).
	20	10	1	9	213D; 119D; 183D; 198D; 5 averaged 180D(e).
	23	10	2	8	128D; 58D; 67D; 5 averaged 110D(e).
	24	1	0	1	139D.
	26	3	0	3	296D; 200D (e); 225D (e).
	28	10	0	10	134D; 129D; 96D; 125D; 164D; 5 averaged 105D.
	29	2	1	1	108D.
	31	1	0	1	143D.
Aug.	1	3	0	3	195D; 97D; 128D.
	4	1	0	1	238D.
	6	1	0	1	173D.
	7	1	0	1	143D.
	18	4	0	4	106D; 88D; 118D; 138D.

DATANA MINISTRA

July	23	7	0	7	Averaged 248D.
	24	4	0	4	81D; 172D; 93D; 125D.
	26	1	0	1	81D.
	29	1	0	1	76D.
	30	3	0	3	91D; 141D; 224D.
Aug.	1	1	0	1	6D.
	3	1	0	1	263D.
	4	1	0	1	332D.

[a] (e)=Estimated.

TABLE III.—*Condition of the ovaries of Lepidoptera taken at a light trap, Hagerstown, Md., 1916*—Continued

ARSILONCHE ALBOVENOSA

Date.	Number taken.	Condition of ovaries. Spent.	Condition of ovaries. Gravid.	Number and development of eggs.
July 4	3	0	3	157S; 173S; 186S.
10	2	0	2	377D; 272D.
13	1	0	1	182S.
Aug. 17	1	0	1	357—198D and 159S.
19	2	0	2	315—153D and 162S; 52D; 162S.
23	2	0	2	213D; 263D.

AUTOGRAPHA BILOBA

Date.	Number taken.	Spent.	Gravid.	Number and development of eggs.
July 4	1	1	0	
Aug. 15	1	1	0	

AUTOGRAPHA SIMPLEX

Date.	Number taken.	Spent.	Gravid.	Number and development of eggs.
June 23	15	5	10	Immature; not counted.
28	3	0	3	78D; 113D; 67D.
29	1	0	1	151D.
July 1	9	3	6	Averaged 123D.
2	7	2	5	Averaged 146D.
4	1	1	0	
6	6	0	6	Averaged 92D.
7	6	0	6	Averaged 79D.
8	12	4	8	Averaged 88D.
27	1	1	0	
30	1	0	1	128D.
Aug. 1	1	0	1	145D.
3	1	1	0	
4	2	2	0	
8	3	0	3	78D; 75D; 75D.
Oct. 4	2	0	2	156D; 168D.

MELIANA DIFFUSA

Date.	Number taken.	Spent.	Gravid.	Number and development of eggs.
June 23	1	1	0	
29	3	2	1	75D.
July 19	1	0	1	78D.
Aug. 9	1	0	1	54D.
10	2	0	2	59D; 64D.
16	1	0	1	79D.
20	1	1	0	
21	2	2	0	
24	2	2	0	
25	1	0	1	79D.
28	1	1	0	
31	1	1	0	
Sept. 2	2	2	0	

TABLE III.—*Condition of the ovaries of Lepidoptera taken at a light trap, Hagerstown, Md., 1916*—Continued

POLIA RENIGERA

Date.		Number taken.	Condition of ovaries. Spent.	Condition of ovaries. Gravid.	Number and development of eggs.[a]
June	23	11	1	10	Averaged 60D.
	28	6	2	4	63D; 42D; 53D; 68D.
	29	22	3	19	Averaged 52D.
July	1	8	0	8	Averaged 73D.
	3	12	2	10	Averaged 39D.
	6	3	1	2	23D; 75D.
	8	4	0	4	51D; 28D; 43D; 73D.
	10	2	0	2	32D; 43D.
	24	1	0	1	38D.
Aug.	22	1	0	1	43D.
	23	7	1	6	Averaged 57D.

CAENURGIA ERECHTEA

Date.		Number taken.	Condition of ovaries. Spent.	Condition of ovaries. Gravid.	Number and development of eggs.[a]
June	28	8	2	6	4 averaged 42D; 125S(e); 150S(e).
	29	11	4	7	Averaged 51D.
July	1	39	13	26	16 averaged 53D; 10 averaged 125S(e).
	2	18	7	11	6 averaged 29D; 5 averaged 125S(e).
	3	63	21	42	30 averaged 62D; 12 averaged 130S.
	4	20	8	12	9 averaged 44D; 3 averaged 110S.
	6	38	10	28	25 averaged 47D: 3 averaged 150S(e).
	7	44	12	32	30 averaged 45D; 2, 125S each (e).
	8	97	49	48	40 averaged 57D; 8 averaged 150S(e).
	10	7	2	5	Averaged 43D.
	14	2	0	2	26D; 21D.
	18	5	3	2	23D; 26D.
	19	11	6	5	Averaged 28D.
	20	12	4	8	Averaged 31D.
	23	17	7	10	Averaged 51D.
	24	6	3	3	27D; 54D; 100D.
	26	6	2	4	Averaged 104D.
	28	1	0	1	86D.
	29	1	1	0	
	30	4	4	0	
Aug.	1	1	0	1	21D.
	2	1	1	0	
	3	10	5	5	Averaged 59D.
	4	3	2	1	19D.
	7	1	0	1	34D.
	8	12	5	7	Averaged 55D.
	9	6	5	1	33D.
	10	44	23	21	18 averaged 32D; 3 averaged 130S(e).
	12	2	1	1	6D.
	13	1	1	0	
	14	3	3	0	
	15	13	7	6	75D; 5 averaged 22D.
	16	5	2	3	16D; 31D; 23D.
	17	18	7	11	8 averaged 53D, 3 averaged 130S(e).
	18	12	7	5	4 averaged 43D; 175S(e).
	19	10	6	4	Averaged 25D.
	20	9	5	4	Averaged 44D.
	21	23	11	12	9 averaged 46D; 3 averaged 150S(e).
	22	31	20	11	10 averaged 42D; 1, 125S(e).
	23	62	36	26	19 averaged 40D; 7 averaged 125S(e).
	24	38	24	14	10 averaged 43D; 4 averaged 110S(e).

[a] (e)=Estimated.

TABLE III.—*Condition of the ovaries of Lepidoptera taken at a light trap, Hagerstown, Md., 1916*—Continued

CAENURGIA ERECHTEA—continued

Date.		Number taken.	Condition of ovaries.		Number and development of eggs.[a]
			Spent.	Gravid.	
Aug.	25	40	22	18	15 averaged 36D; 3 averaged 75S(e).
	28	3	1	2	24D; 32D.
	30	24	13	11	9 averaged 34D, 75S(e); 100S(e).
	31	24	14	10	Averaged 30D.
Sept.	1	13	3	10	Averaged 31D.
	2	5	4	1	23D.
	14	6	1	5	Averaged 51D.
	18	1	1	0	
Oct.	6	2	1	1	22D.

CAENURGIA CRASSIUSCULA

Date.		Number taken.	Spent.	Gravid.	Number and development of eggs.[a]
June	28	4	1	3	96D; 108D; 57D.
	29	4	2	2	53D; 28D.
July	1	19	7	12	8 averaged 53D; 4 averaged 125S(e).
	2	9	3	6	3 averaged 29D; 3 averaged 125S(e).
	3	29	10	19	11 averaged 62D; 8 averaged 130S(e).
	4	10	4	6	3 averaged 44D; 3 averaged 110S.
	6	21	6	15	13 averaged 47D; 2, 150S(e).
	7	22	6	16	13 averaged 45D; 3 averaged 125S(e).
	8	51	29	22	17 averaged 51D; 5 averaged 150S(e).
	10	4	1	3	29D; 43D; 21D.
	14	2	1	1	47D.
	18	4	0	4	Averaged 25D.
	19	6	3	3	Averaged 67D.
	20	9	7	2	19D; 16D.
	23	3	1	2	81D; 56D.
	24	1	1	0	
	26	3	2	1	128S.
Aug.	1	1	1	0	
	2	2	2	0	
	3	5	3	2	100D; 25D.
	6	2	2	0	
	8	6	3	3	21D; 100S(e); 100S(e).
	9	5	4	1	75D.
	10	13	8	5	3 averaged 32D; 100S(e); 100S(e).
	12	3	3	0	
	13	2	0	2	41D; 31D.
	14	5	5	0	
	15	24	13	11	8 averaged 22D; 3 averaged 75S.
	16	8	4	4	Averaged 31D.
	17	20	9	11	7 averaged 53D; 4 averaged 130S(e).
	18	23	12	11	8 averaged 43D; 3 averaged 100S(e).
	19	19	11	8	Averaged 38D.
	20	17	9	8	Averaged 44D.
	21	25	13	12	10 averaged 40D; 125S(e); 175S(e).
	22	68	40	28	22 averaged 42D; 6 averaged 125S(e).
	23	63	37	26	20 averaged 40D; 6 averaged 125S(e).
	24	13	6	7	6 averaged 43D; 125S(e).
	25	15	9	6	5 averaged 36D; 100S(e).
	28	2	1	1	64D.
	30	12	6	6	5 averaged 34D; 75S.
	31	8	4	4	Averaged 30D.
Sept.	2	3	1	2	42D; 28D.
	14	1	0	1	75D.

[a] (e)=Estimated.

TABLE III.—*Condition of the ovaries of Lepidoptera taken at a light trap, Hagerstown, Md., 1916*—Continued

CIRPHIS UNIPUNCTA

Date.		Number taken.	Condition of ovaries. Spent.	Gravid.	Number and development of eggs.[a]
June	28	4	0	4	578D; 539D; 550D; 575D.
	29	3	0	3	638D; 619D; 543D.
July	1	19	6	13	118D; 483D; 648D; 10 averaged 475D(e).
	2	7	1	6	397D; 378D; 586D; 3 averaged 400D(e).
	3	42	10	32	4 averaged 362D; 28 averaged 375D(e).
	4	13	3	10	523D; 618D; 703D; 600D(e); 550D(e); 525D(e); 575D(e); 500D(e); 525D(e); 325D(e).
	6	13	1	12	638D; 679D; 587D; 9 averaged 535D(e).
	7	90	11	79	128D; 383D; 744D; 773D; 75 averaged 525D(e).
	8	57	21	36	625D; 587D; 634D; 718D; 32 averaged 365D(e).
	10	22	5	17	625D; 473D; 587D; 713D; 13 averaged 505D(e).
	18	10	2	8	713D; 628D; 478D; 5 averaged 475D(e).
	19	14	3	11	554D; 623D; 478D; 8 averaged 512D(e).
	20	12	0	12	657D; 713D; 538D; 9 averaged 530D(e).
	23	19	8	11	107D; 78D; 576D; 8 averaged 565D(e).
	24	2	2	0	
	27	6	2	4	663D; 587D; 713D; 629D.
	28	8	1	7	684D; 593D; 567D; 4 averaged 550D(e).
	29	3	0	3	567D; 627D; 493D.
	30	5	0	5	692D; 563D; 478D; 450D(e); 525D(e).
	31	4	1	3	613D; 576D; 550D(e).
Aug.	1	4	0	4	273D; 438D; 557D; 425D.
	2	2	0	2	397D; 453D.
	3	15	2	13	625D; 583D; 518D; 10 averaged 477D(e).
	4	11	0	11	576D; 487D; 682D; 8 averaged 528D(e).
	6	5	0	5	718D; 700D; 475D; 525D; 375D.
	7	1	0	1	378D.
	8	6	0	6	486D; 726D; 4 averaged 550D(e).
	9	7	0	7	623D; 6 averaged 495D(e).
	10	10	3	7	387D; 658D; 5 averaged 480D(e).
	11	5	1	4	487D; 633D; 550D(e); 425D(e).
	16	1	1	0	
	19	1	0	1	563D.
	22	2	0	2	432D; 328D.
Sept.	27	1	1	0	

NOCTUA C-NIGRUM

Aug.	8	5	3	2	Fully developed; not counted.
	9	13	10	3	Do.
	10	7	5	2	Do.
	11	2	2	0	
	14	1	0	1	Do.
	15	1	0	1	Do.
	18	7	2	5	Do.
	21	2	1	1	Do.
	22	11	7	4	Do.
	23	15	8	7	Do.
	24	13	6	7	Do.
	25	7	3	4	Do.
	30	7	3	4	218D; 198D; 238D; 1 not counted.
	31	5	2	3	Fully developed; not counted.
Sept.	1	1	1	0	

[a] (e)=Estimated.

TABLE III.—*Condition of the ovaries of Lepidoptera taken at a light trap, Hagerstown, Md., 1916*—Continued

NOCTUA C-NIGRUM—continued

Date.	Number taken.	Condition of ovaries. Spent.	Condition of ovaries. Gravid.	Number and development of eggs.[a]
Sept. 2	2	0	2	Fully developed; not counted.
14	2	2	0	
18	3	1	2	Do.
Oct. 6	3	2	1	Do.

FELTIA SPP.

Date.	Number taken.	Spent.	Gravid.	Number and development of eggs.[a]
Aug. 8	4	0	4	200D(e); 200D(e); 300S(e); 300S(e).
9	3	1	2	69D; 198D.
10	3	1	2	154D; 300S(e).
12	1	0	1	43D.
14	1	0	1	233D.
15	3	1	2	73D; 250S(e).
17	1	0	1	432S.
18	1	0	1	254D.
19	1	0	1	238D.
20	3	0	3	101D; 154D; 298D.
21	14	1	13	78D; 158D; 149D; 98D; 228S; 4 averaged 288S; 4 averaged 213D.
22	43	10	33	7 averaged 163D; 22 averaged 112D; 4 averaged 250S(e).
23	38	5	33	7 averaged 117D; 20 averaged 130D(e); 6 averaged 258S(e).
24	38	10	28	112D; 183D; 74D; 81D; 218D; 228S; 258S; 16 averaged 113D(e); 5 averaged 230S(e).
25	65	20	45	10 averaged 120D; 5 averaged 277S; 21 averaged 125D(e); 9 averaged 293S(e).
28	8	2	6	258D; 128D; 178D; 151D; 200S(e); 200S(e).
30	75	16	59	128D; 78D; 64D; 159D; 235S; 346S; 271S; 43 averaged 115D(e); 9 averaged 225S(e).
31	57	32	25	128D; 174D; 64D; 152D; 137D; 154D; 176D; 8 averaged 120D(e); 10 averaged 219S(e).
Sept. 1	33	6	27	221D; 153D; 186D; 131D; 74D; 68D; 18 averaged 154D(e); 200S(e); 200S(e); 468S.
2	26	6	20	78D; 153D; 47D; 53D; 5 averaged 100D; 11 averaged 136D(e).
4	11	10	1	141D.
5	10	9	1	128D.
7	11	7	4	18D; 209D; 74D; 199D.
14	127	91	36	236D; 158D; 95D; 101D; 128D; 86D; 30 averaged 94D(e).
18	54	47	7	196D; 156D; 116D; 76D; 226S; 125D(e); 50D(e).
27	37	29	8	86D; 180D; 76D; 226D; 4 averaged 88S(e).
28	85	48	37	96D; 126D; 233D; 76D; 56D; 74D; 101D; 30 averaged 120D(e).
Oct. 6	45	42	3	219D; 48D; 54D.

[a] (e)=Estimated.

The one species (*Datana ministra*) of the Notodontidae is represented by 19 females, all of which were gravid.

Among the Noctuidae all the females of one species (*Arsilonche albovenosa*) were found to be gravid. One species, *Autographa biloba*, is

represented by only 2 females, both spent. Of the remaining species of this family the percentage of gravid females varies from 37 per cent in *Meliana diffusa* to 87 per cent in *Polia renigera*. Of the 424 females of *Cirphis unipuncta* dissected, 80 per cent were gravid, the eggs ranging in number from 107 to 773, all fully developed.

Some explanation is required as to the method of arriving at the number of eggs accredited to a female moth where a footnote to a table reads "Estimated." The ovarian structure was dissected and spread for counting the eggs, adopting a unit of 25 eggs. The remaining ovarian material was divided into masses of the bulk of that containing 25 eggs. This method was frequently verified by actual counts and it is believed that the figures are dependable. Where no such reference appears, the actual count was made. In every case the stage of development was determined under the hand lens or binocular and indicated in Table III by "D" for "developed" and by "S" for "immature."

Any data as to the relative proportions of male and female Lepidoptera taken at a light trap have an added value when considered in connection with information bearing on these relations of the sexes in nature. For this reason the writer has endeavored to get together all facts to be had from available sources, and brief notes on the subject are cited here under the name of the species concerned.

EUPROCTIS CHRYSORRHOEA LINNAEUS (*3, p. 47-48*)[1]

Concerning the brown-tail moth Fernald and Kirkland write as follows:

> In July, 1897, a quantity of cocoons and pupæ was gathered and placed in a large glass-covered box, the moths being removed as they emerged. The following . . . shows the relative proportion of the sexes: Males, 399; females, 451.

ELASMOPALPUS LIGNOSELLUS ZELLER (*10, p. 20*)

Records obtained at Columbia, S. C., in 1915. From 56 pupæ there emerged 23 males and 33 females.

PHTHORIMAEA OPERCULELLA ZELLER (*4, p. 24*)

Graf records the following data with regard to the proportion of sexes of the potato-tuber moth:

> The proportion of the sexes during the year remains very nearly constant and almost equal. Pupæ selected at random at various times of the year gave the results shown in Table 3. (327 males, 284 females.)

CRAMBUS HORTUELLUS HUEBNER (*15, p. 8*)

With regard to the cranberry girdler, Scammell records the following data:

> In the early summer the males and females appear to be about equal in number; for example, on June 11, 24 moths were collected, of which 12 were males and 12 females. In late summer, however, the males are far in excess of the females, as shown by the following collections: Thirteen moths taken July 27 consisted of 11 males and 2 females, while of 23 moths collected August 10 only 5 were females.

[1] Reference is made by number (italic) to "Literature cited," p. 148-149.

PLUTELLA MACULIPENNIS CURTIS (*11, p. 5*)

Information as to the proportional relations of the two sexes in this species is not particularly definite in the paper by Mr. Marsh, his statement being: "Fifty-two adults, about equally divided as to sex, developed on November 2 and 3." In the summing up of such data as the writer has been able to assemble, this species appears in Table XX as 26 males and 26 females.

CARPOCAPSA POMONELLA LINNAEUS (*16*)

A general deduction from all data given of rearings puts the proportional relations of the sexes as nearly equal, with a very slight preponderance of females. The same species (*5, p. 52*) is reported by Mr. A. G. Hammar as including 456 males and 563 females in a total of 1,019 individuals. Further information as to the codling moth is to be found in the paper by Messrs. Jones and Davidson (*9, p. 120–121*), where, in Table VI, the moths issuing from 151 pupæ are shown to comprise 67 males and 84 females. In Table XXIX (*9, p. 146*), of 65 adults 32 are reported as males, 33 as females, while in Table XL (*9, p. 153*) the males make up only 21 of a total of 54. Summing up the data for *C. pomonella* it is found that of 1,289 individuals the males include 576; the females 713; a percentage of 44.7 and 55.3, respectively.

SANNINOIDEA OPALESCENS HENRY EDWARDS (*12, p. 79*)

Mr. Dudley Moulton in his records for 1908 and 1909 on this species accounts for 232 adults and lists them as 118 males, 114 females.

SYNANTHEDON PICTIPES GROTE AND ROBINSON (*8, p. 411*)

Mr. J. L. King, in his paper on the lesser peach-tree borer, places 12 adults as to sex; 4 are determined as males and 8 as females. On the same page of the bulletin five adults are divided as to sex into 2 males and 3 females.

ARCHIPS ARGYROSPILA WALKER (*6, p. 257*)

Messrs. Herrick and Leiby had under observation 227 pupæ from larvæ kept in jars "in an open air insectary under normal conditions of temperature." Sex determinations of 155 individuals proved 85 to be males and 70 to be females.

The same species was under observation by Mr. W. M. Davidson (*2*) in 1911, who states that of 76 adults 29 were males and 47 were females.

ARCHIPS ROSACEANA HARRIS (*14, p. 396*)

In an article by E. D. Sanderson and Mrs. A. D. Jackson, published in the Journal of Economic Entomology, December, 1909, the authors state that from 62 pupæ there issued 35 males and 27 females.

HALISIDOTA CARYAE HARRIS (*7, p. 8*)

Mr. Dwight Isely had this species under observation at North East, Pa., during the summers of 1915 and 1916. He records that of 25 adults reared 17 were males and 8 were females.

CHLORIDEA OBSOLETA FABRICIUS (*13, p. 92*)

Of this species it is stated that—

> . . . data concerning over 300 moths were collected which bear evidence on the proportions of the sexes. These include records of moths collected in the field and of those bred out in the laboratory. In practically all cases there is a slight preponderance of females in the ratio of 168 females to 120 males.

HEMILEUCA OLIVIAE COCKERELL (*1, p. 84, 88*)

In his paper on this species Mr. C. N. Ainslie says:

> During the first week of emergence the males outnumbered the females at least three to one, and on page 88 a table shows that from 5,000 pupæ gathered in widely separated parts of the infested area there emerged 2,822 males as against 2,178 females.

Further information concerning this species is had from manuscript records on the relative proportions of the sexes, compiled from pupal parasite cages at Koehler, N. Mex., by Messrs. V. L. Wildermuth, D. J. Caffrey, and H. E. Smith, during September, October, and November, 1913. These records concern a total of 19,321 moths, of which 10,844 were males and 8,477 were females.

PORTHETRIA DISPAR LINNAEUS

Under date of December 15, 1917, Mr. F. H. Mosher, Entomological Assistant, states that of the large number of gipsy moths reared in investigations extending over a period of six years the ratio of males to females averaged as 5 to 4, a percentage of 55.6 and 44.4, respectively.

A summing up of the foregoing notes on the proportional relations of the sexes in the Lepidoptera is presented in Table IV, by which it is seen that of 28,094 individuals, the males make up 55 per cent and the females 45 per cent Although 14 species are concerned, the bulk of moths are of one species, *Hemileuca oliviae*. It is to be regretted that the matter of the proportion of sexes among Lepidoptera has received so little attention.

If it be assumed that the sexes exist in nature in approximately equal numbers, the investigations on which this paper is based show the females taken at the light trap to constitute 57 per cent of the assumed total of females, while the gravid females so taken make up 33 per cent. It is believed that further investigations to be conducted will adduce additional evidence to disprove the theory that practically only male

Lepidoptera are attracted to light traps and that of the females so captured all have previously oviposited.

TABLE IV.—*Summary of foregoing records, compiled mainly from the literature, as to the relative proportions of male and female Lepidoptera*

Species.	Number of males.	Number of females.	Total.	Percentage of males.	Percentage of females.
Euproctis chrysorrhoea Linnaeus	399	451	850	47	53
Elasmopalpus lignosellus Zeller	23	33	56	41	59
Phthorimaea operculella Zeller	327	284	611	53.5	46.5
Crambus hortuellus Hübner	41	19	60	68.3	31.7
Plutella maculipennis Curtis	26	26	52	50	50
Carpocapsa pomonella Linnaeus	576	713	1,289	44.7	55.3
Hemileuca oliviae Cockerell	13,666	10,655	24,321	56	44
Sanninoidea opalescens Henry Edwards	118	114	232	50.9	49.1
Synanthedon pictipes Grote and Robinson	6	11	17	35.3	64.7
Archips argyrospila Walker	114	117	231	49.4	50.6
Archips rosaceana Harris	35	27	62	56.5	43.5
Halisidota caryae Harris	17	8	25	68	32
Chloridea obsoleta Fabricius	120	168	288	42	58
Porthetria dispar Linnaeus	....	....	....	55.6	44.4

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